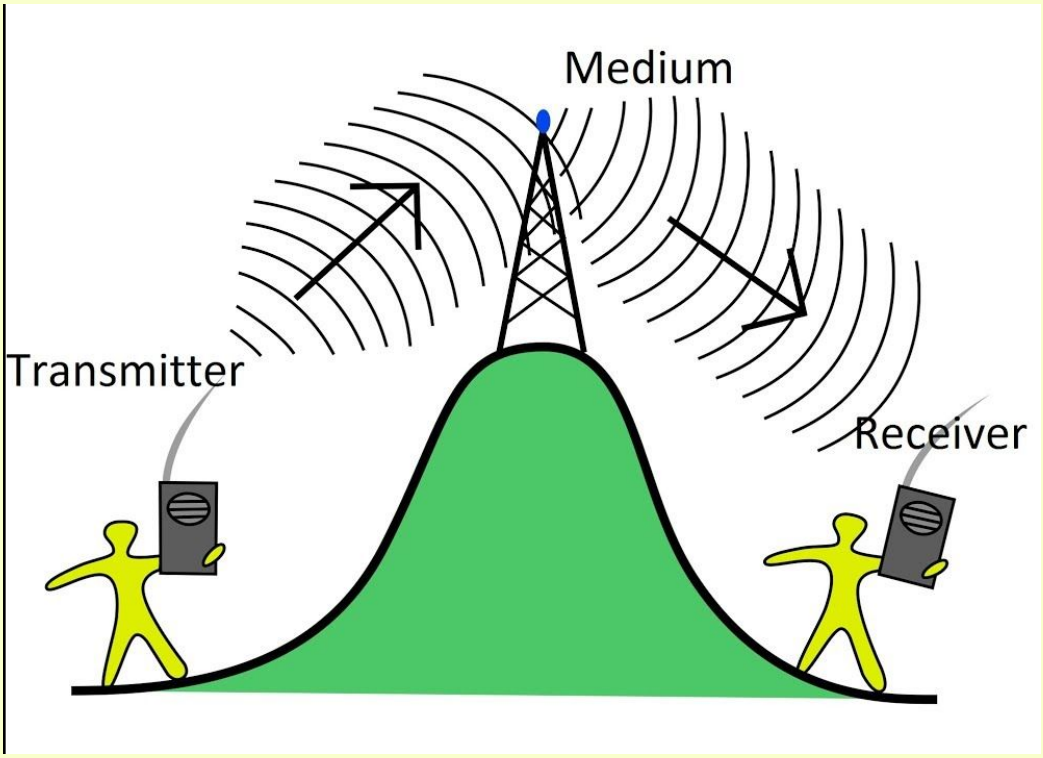
Zewail City of Science and Technology
University of Science and Technology
CIE 428 - fall 2019

Assignment 4



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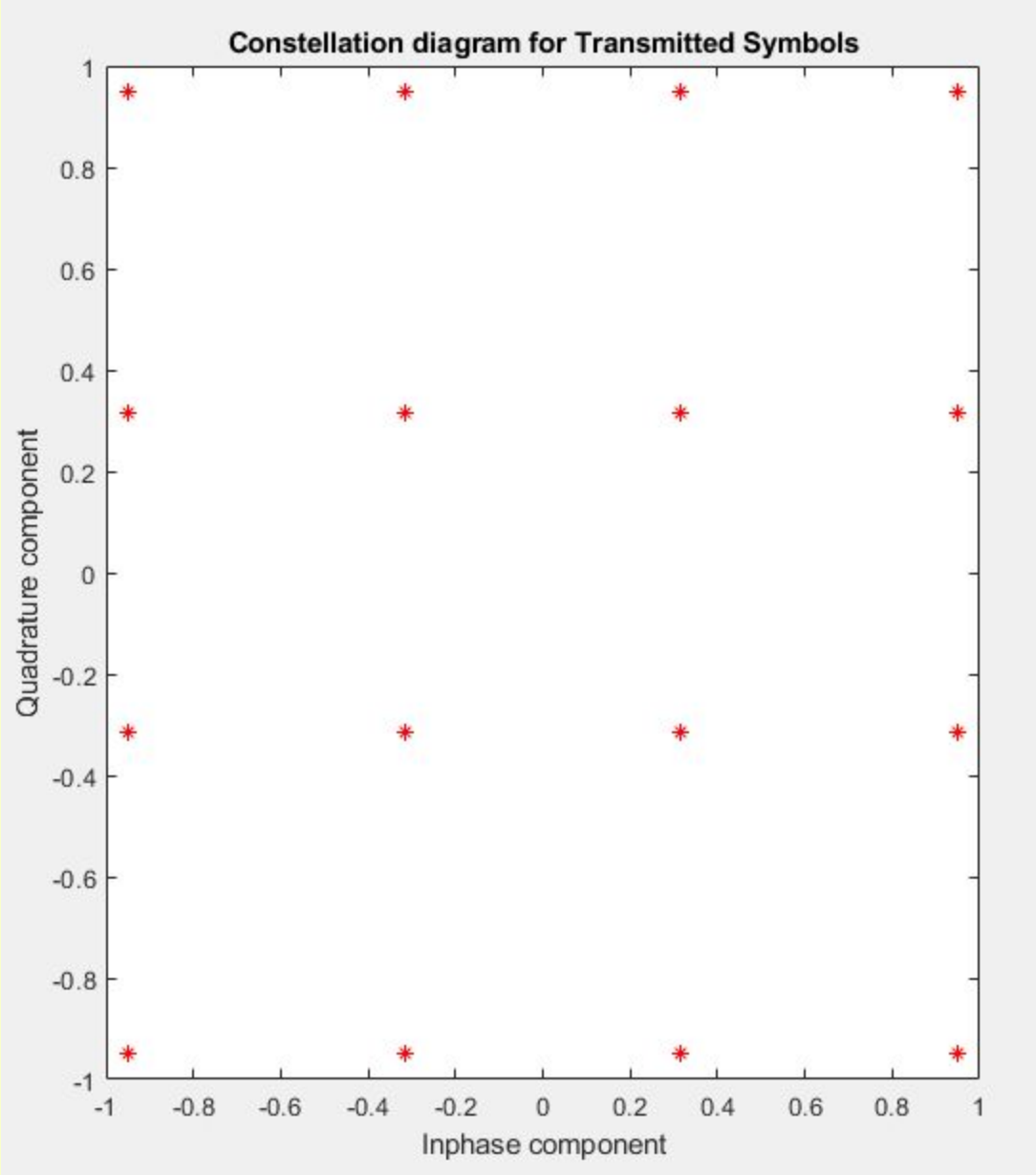
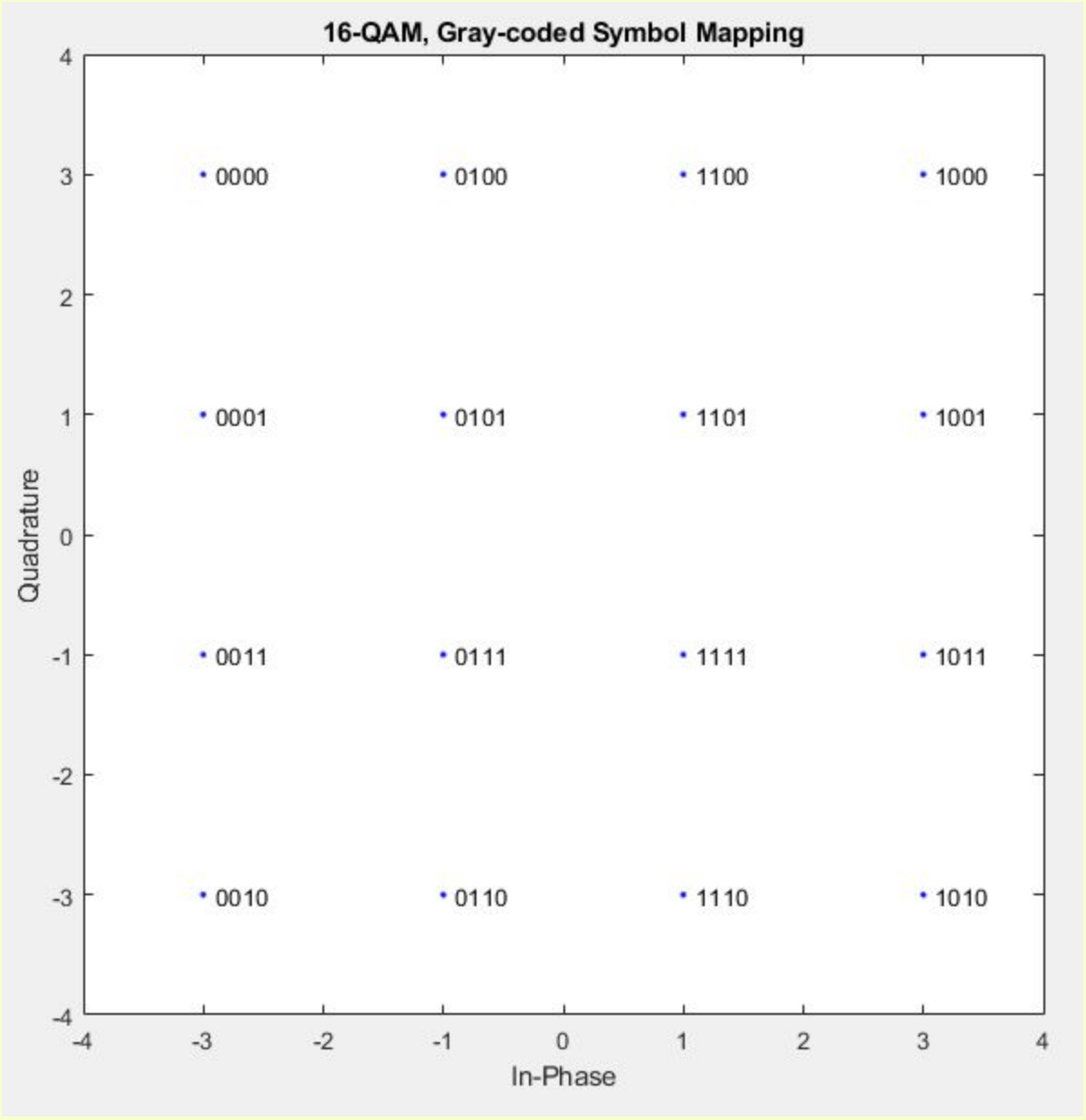
Saturday,November 23, 2019

1 | 16 QAM Figures



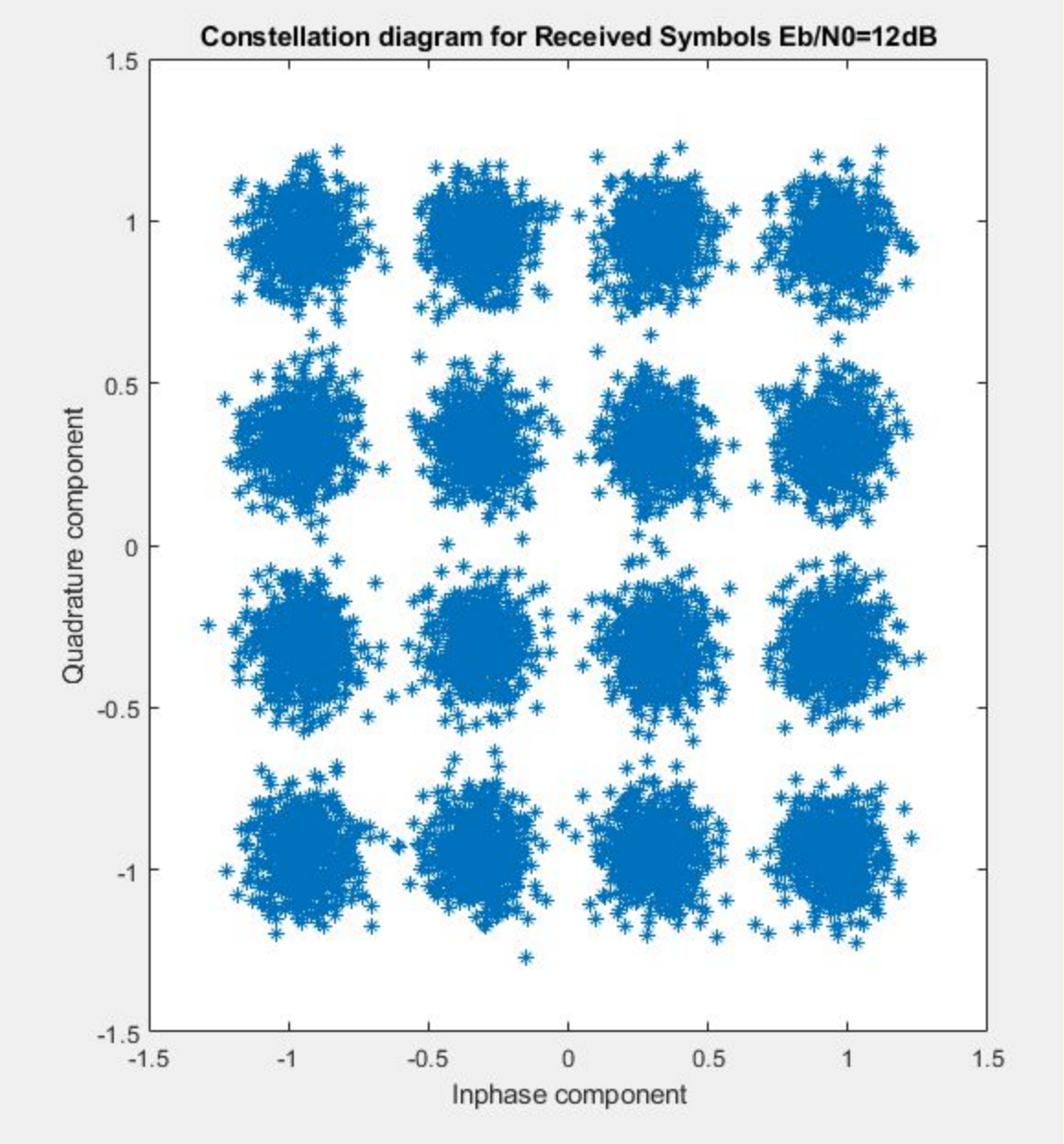
Constellation of the 16 transmitted symbols

Results Comment :There are 16 symbols, the distance between each symbol and its adjacent is fixed .



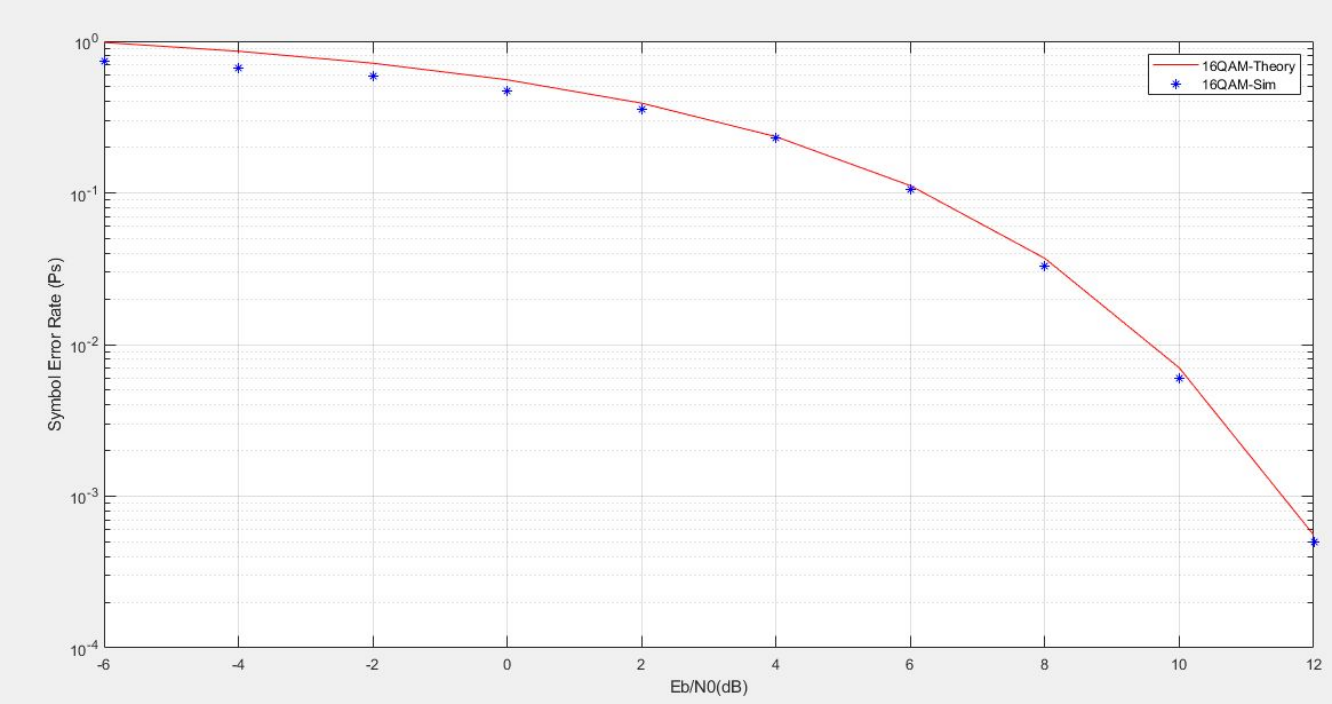
Constellation of the 16 transmitted symbols using gray coding

Results Comment :Gray coding makes any symbol differs from its adjacent symbol in one bit .



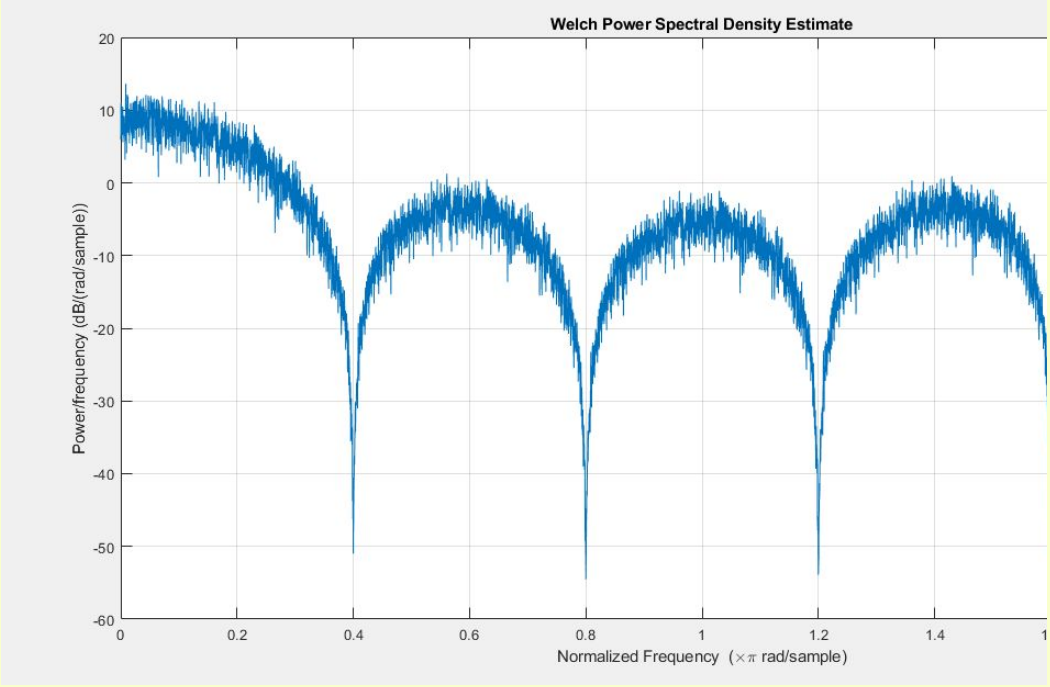
Constellation of the noisy 16 received symbols

Results Comment :Noise makes symbols deviates from its accurate positions , ML rule is used to determine which symbol has been transmitted .



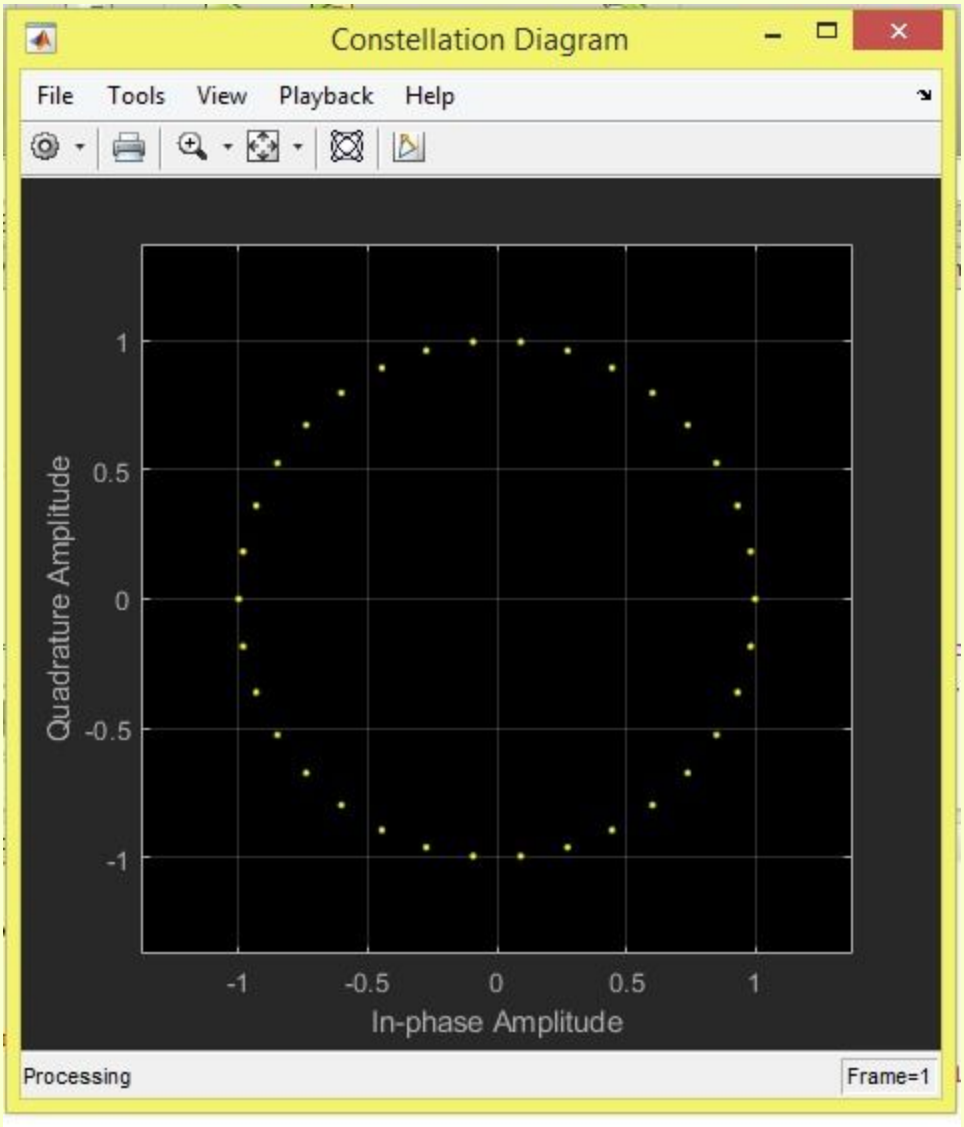
Results comment : The more the SNR , the less the BER .

BER of 16 QAM

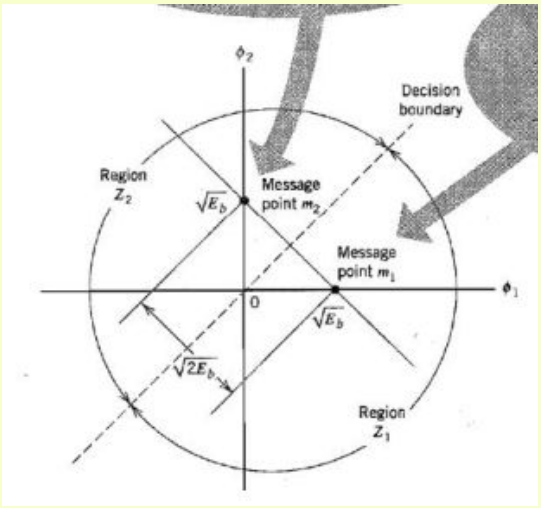


Results comment :As I have used rect function for pulse shaping in time domain , psd is a sinc fcn in freq domain.

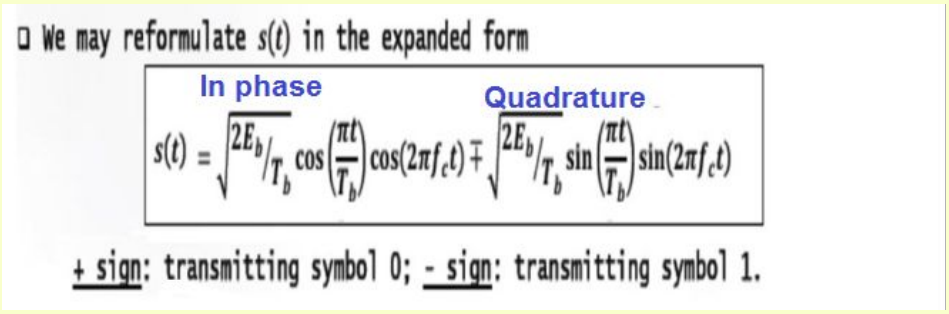
2 | BFSk Figures



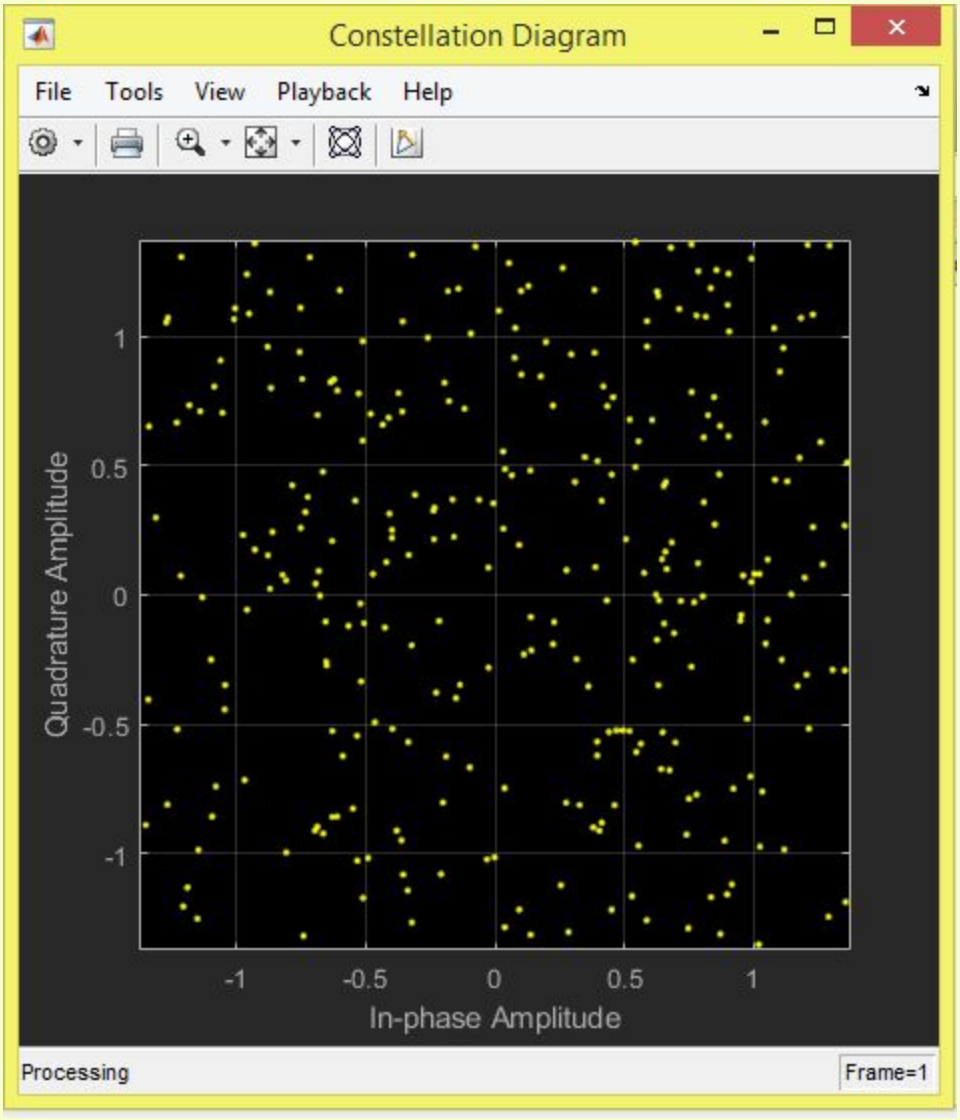
Results comment : Most likely you are expecting to receive a constellation diagram like this



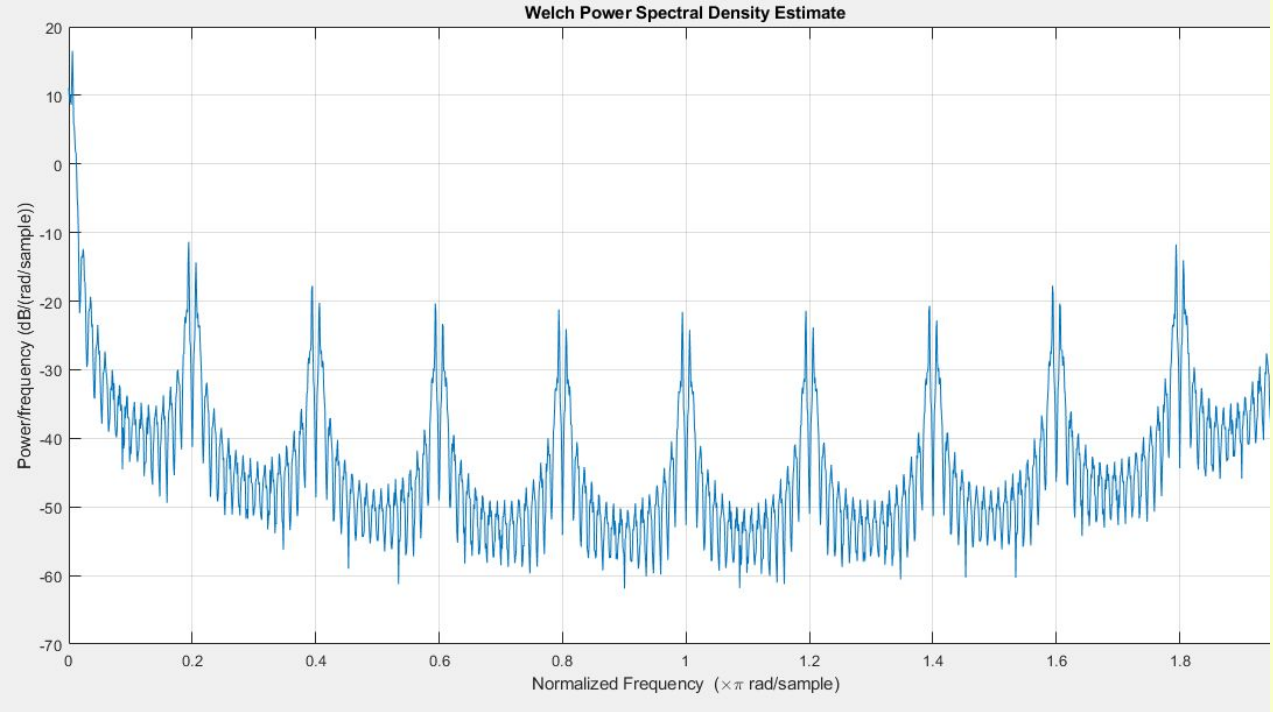
However the other one is also correct as it draws the inphase and quadrature components .



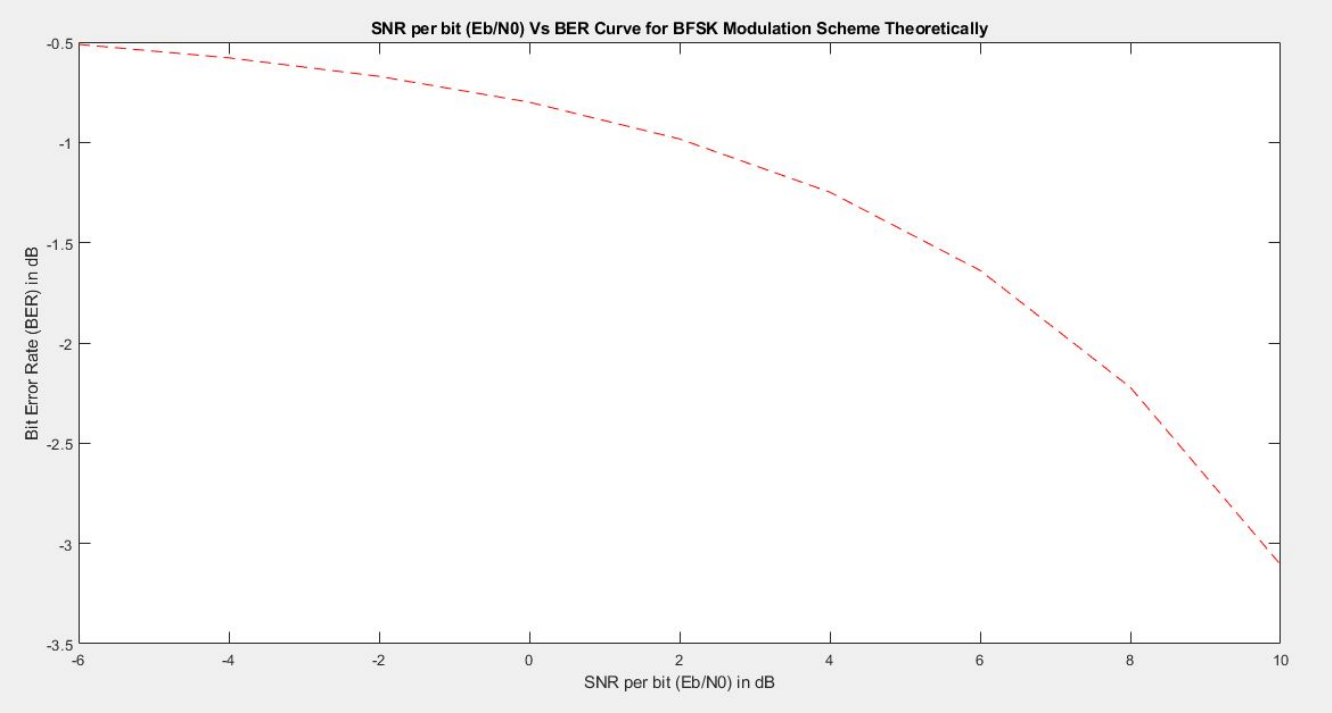
You can get deduce it by correlating it with the two basis function.



Results comment : we can see the effect of noise as it deviates points from circle circumference .

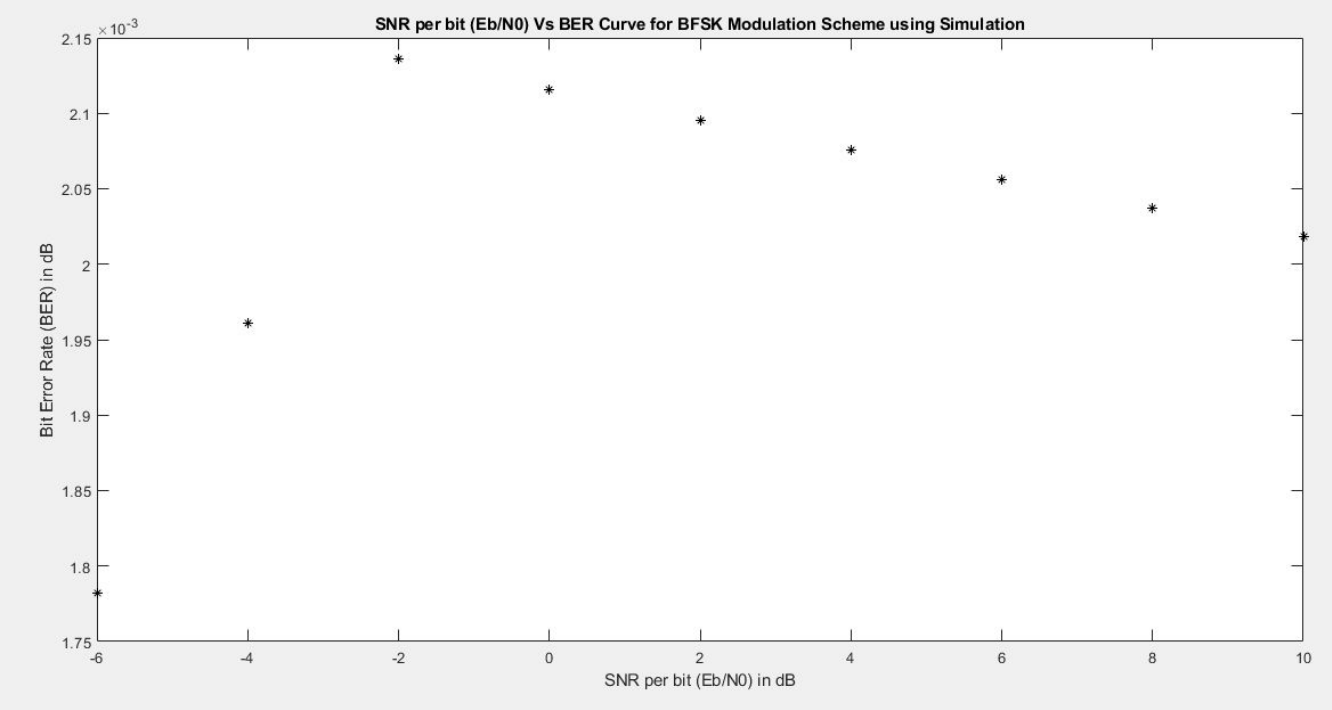


Results comment :As I have used rect function for pulse shaping in time domain , psd is a sinc fcn in freq domain.



SNR per bit (Eb/N0) Vs BER Curve for BFSK Modulation Scheme Theoretically

Results comment : The more the SNR , the less the BER .



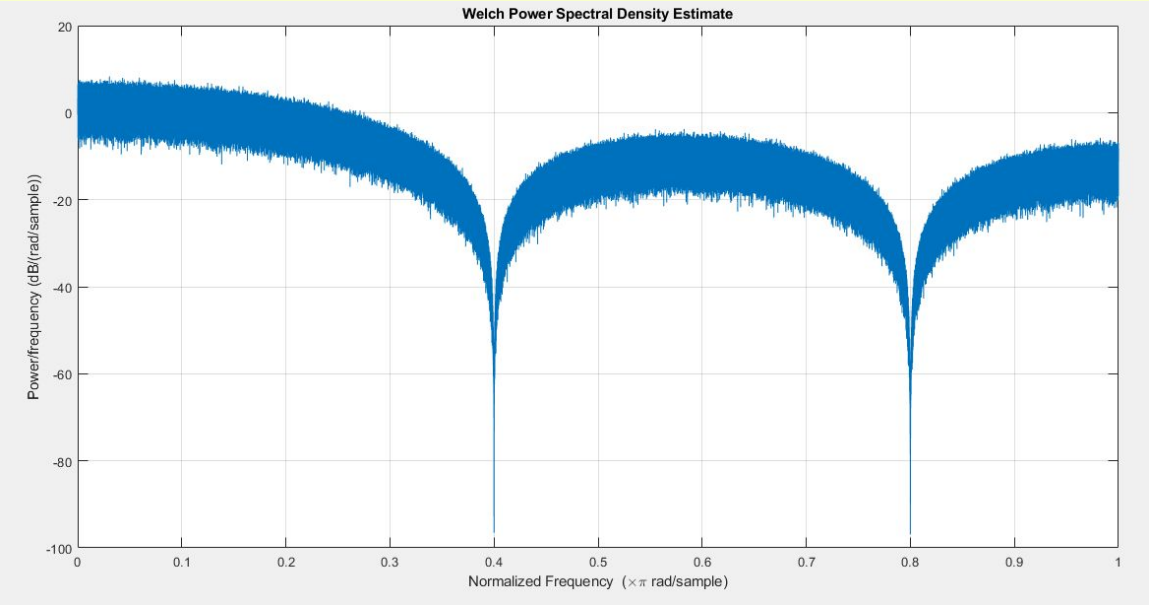
SNR per bit (Eb/N0) Vs BER Curve for BFSK Modulation Scheme using Simulation

Results comment : The more the SNR , the less the BER . There are two points i the whole simulation deviated from this rule , I consider them as outlier .

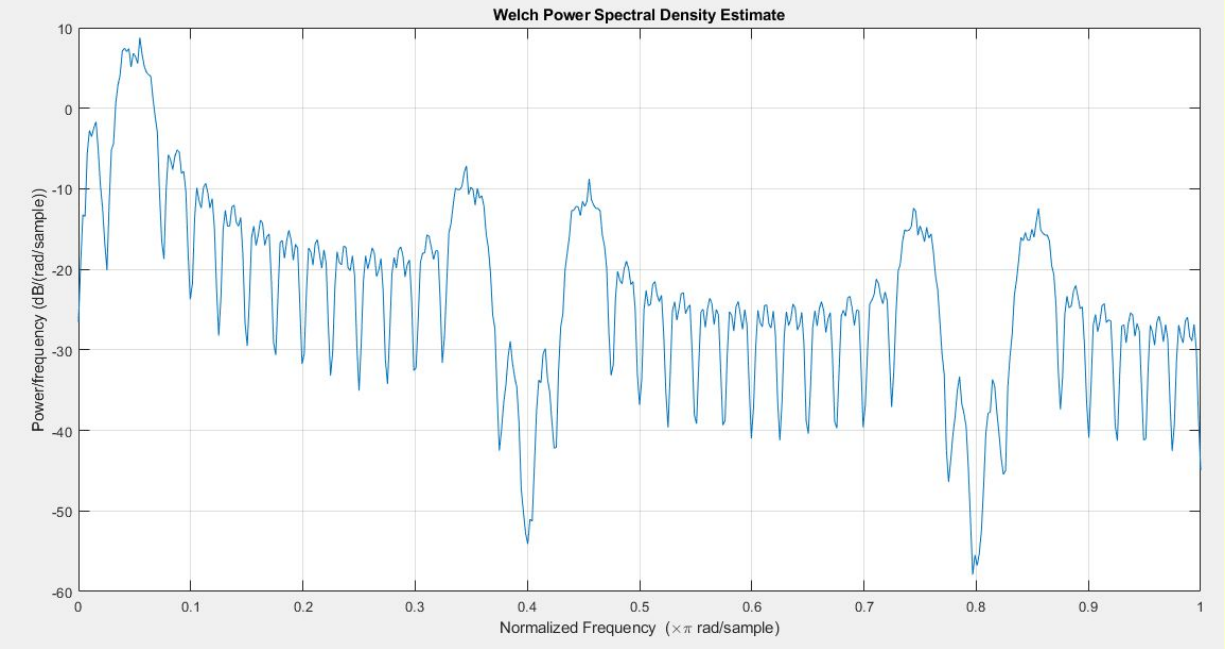
3 | Comparisons

PSD

PSD for Bpsk



PSD of QPSK

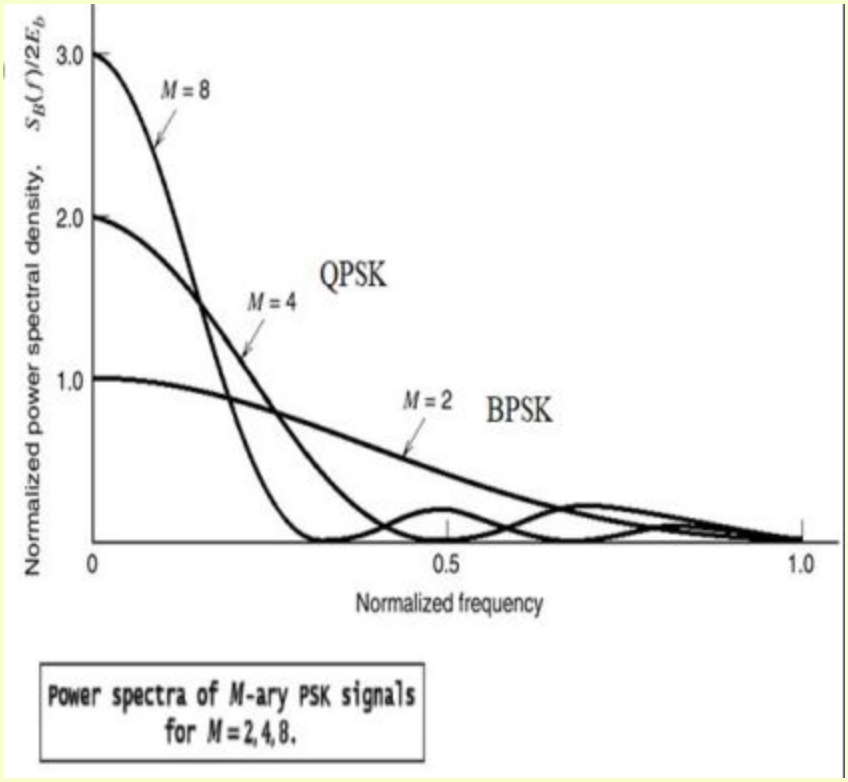


Results comment :There are two observations

1- If we consider -20 db is the first null , then Qpsk reaches first null faster than BPSK.

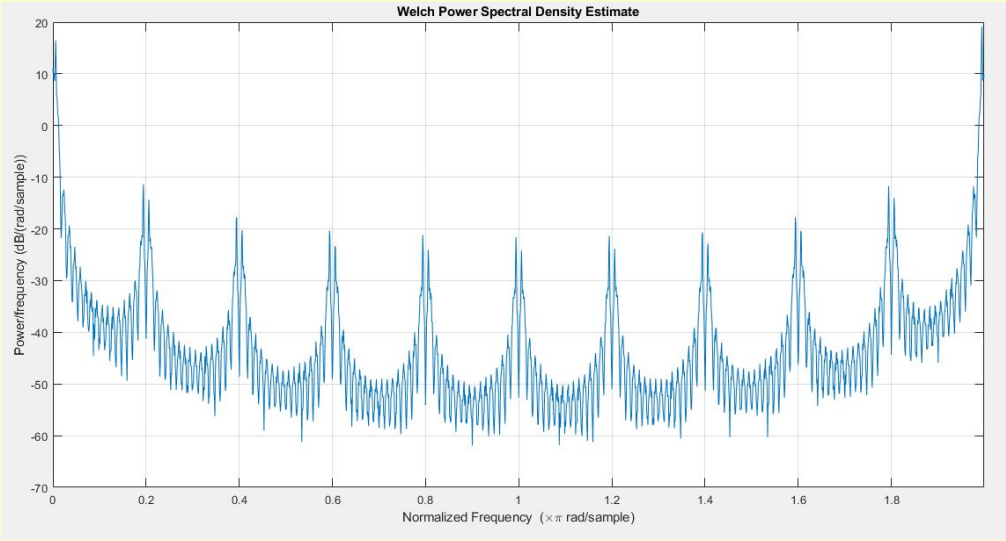
2- Peak value of Qpsk is larger than BPSK .

Both observations are consistent with theory .

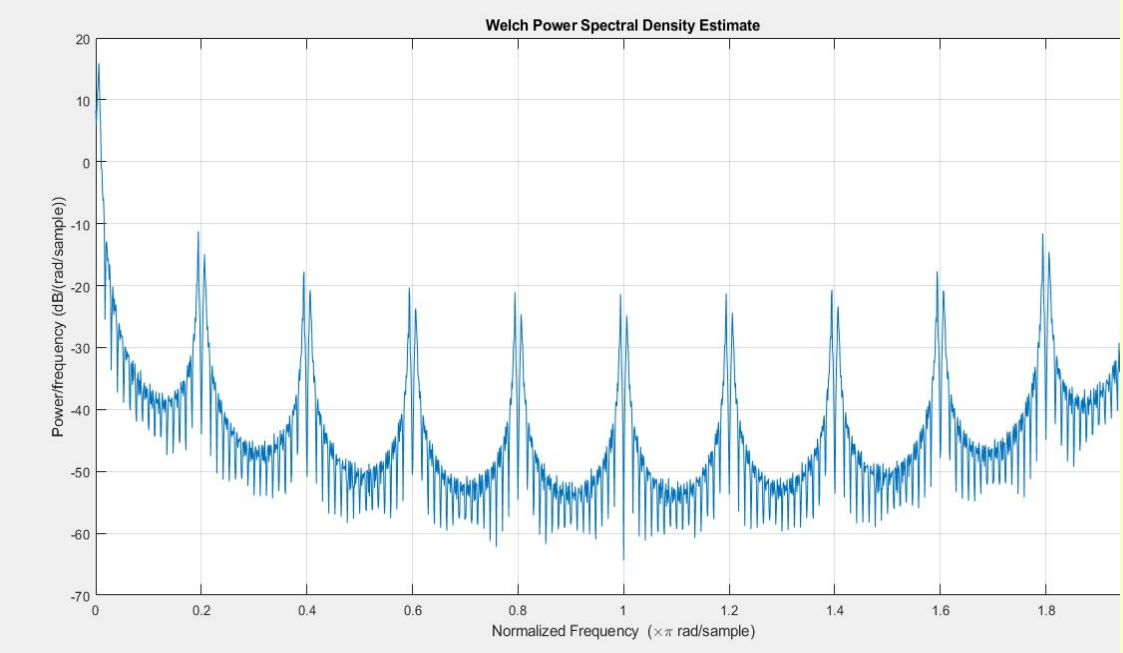


Theoretical relation between QPSK and BPSK

PSD for 16-QAM

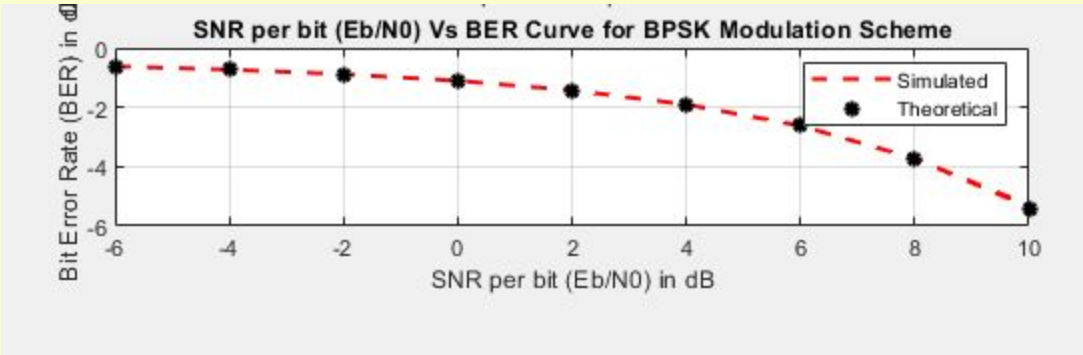


PSD for BFSK

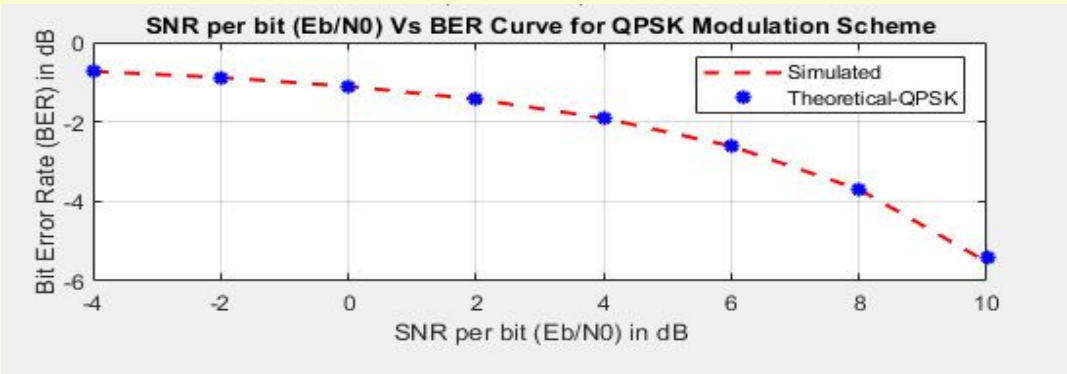


SNR VERSUS BER

For BPSK

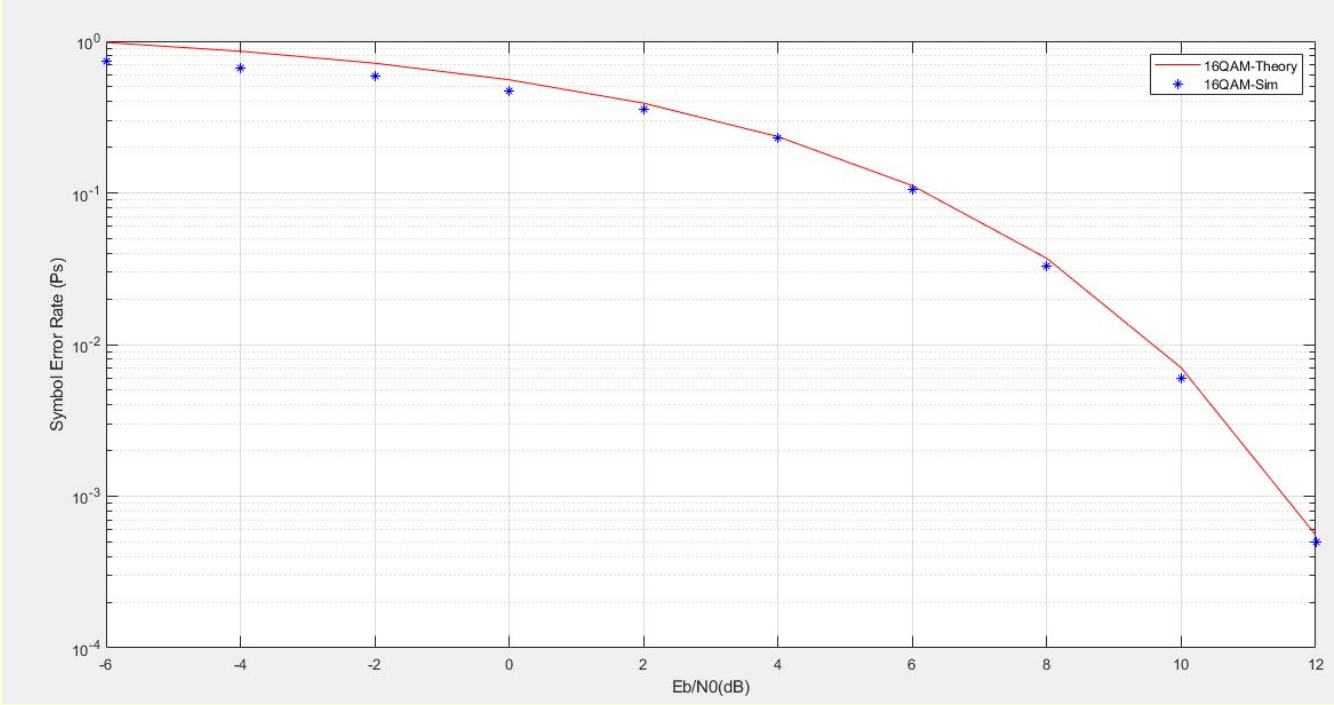


For Qpsk



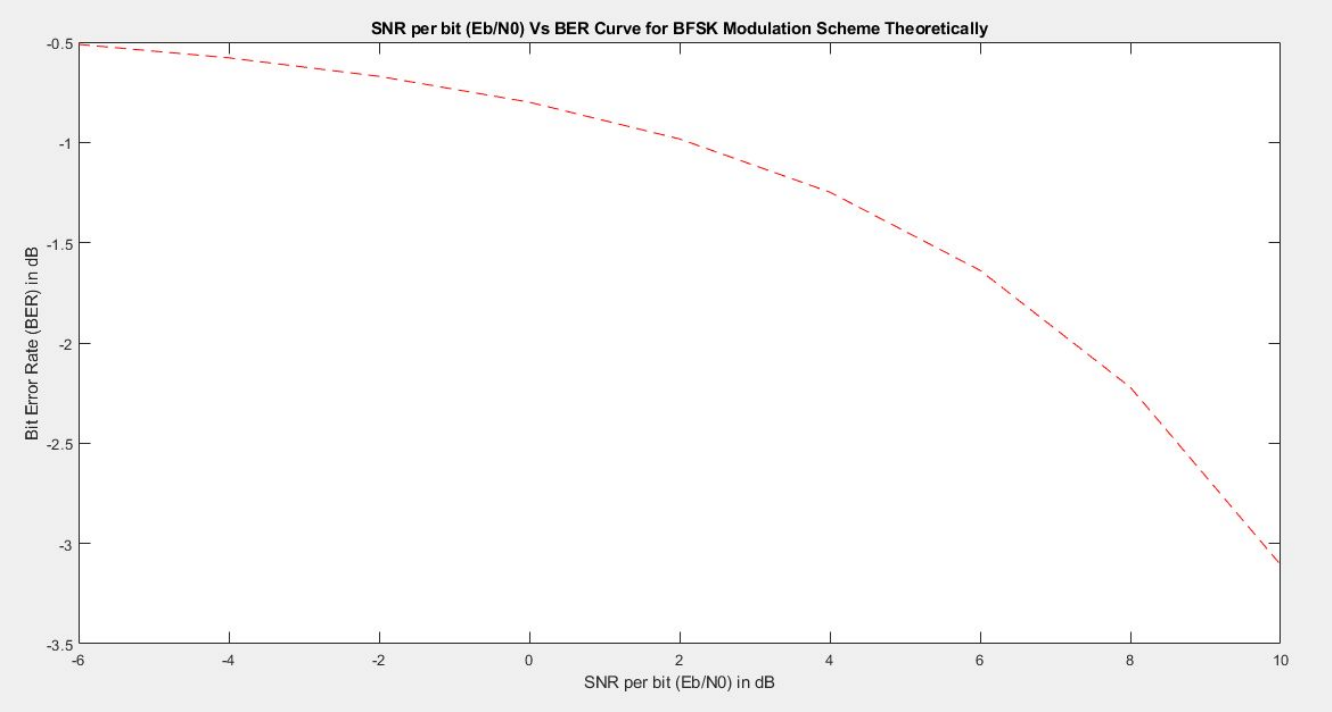
Results comment : We can see BPSK and QPSK have the same BER for same SNR .This is consistent with theory .

For 16-QAM



Results comment : we can see that BER of 16 QAM is larger than BPSK , QPSK for the same SNR which is expected as separation between symbols decreases .

For BFSK



Results comment : If we compared between BFSK receiver to maintain the same BER as in a BPSK receiver , the bit energy to noise density ratio , Eb/N0, has to be doubled .

BPSK: $P_e = \frac{1}{2} erfc\left(\sqrt{\frac{E_b}{N_0}}\right)$ BFSK: $P_e = \frac{1}{2} erfc\left(\sqrt{\frac{E_b}{2N_0}}\right)$

4 | References

[1]Viswanathan, M. (2013). Simulation of digital communication systems using matlab. 2nd ed. Mathuranathan Viswanathan.